much higher vacuum than a reciprocating engine, with a greatly increased efficiency.

Thus the *Olympic,* one of the White Star liners of the largest size—46,440 tons displacement—was fitted with four-cylinder triple-expansion reciprocating engines capable of 30,000 indicated horse-power at 75 revolutions. These exhausted into turbines developing 17,000 shaft horse-power at 165 revolutions.

The reciprocating engines exhaust to the turbines at about 9 Ib. absolute pressure, and the steam is expanded down in the turbines to about i Ib. absolute, the condensing plant being designed for a vacuum of 28^ in. Hg. with a 30 in. barometer.

Though such installations are highly economical, it is probable that gearing will become standard practice for cargo vessels and the like on account of its greater simplicity and the smaller space occupied.

In 1909 gearing was first tried in marine work by the Parsons Marine Steam Company. In order to test the suitability of gearing for interposition between the prime mover and the propeller in ship propulsion, an old steamer, the *Vespasian,* was purchased. This ship was originally equipped with reciprocating engines, and these were replaced by a turbine installation driving through a single-reduction gearing. The gearing in the engine-room of the *Vespasian* with the cover removed is shown in fig. 48.

Particulars of this experiment were fully given by Sir Charles Parsons in a paper read by him before the Institution of Naval Architects.

The trials were entirely satisfactory, and the vessel afterwards ran regularly between the River Tyne and the Continent, carrying coal. During a period in which this vessel steamed about 20,000 miles the machinery gave not the slightest trouble.

In ships in which it is required to keep down staff and where facilities for repair are small, complications are to be avoided, and the helical spur gearing meets this consideration.

In the war vessel all the original installations were equipped with cruising turbines in addition to the installation for full-speed steaming. These cruising turbines were designed to give lower speeds, and were used in

ordinary running when the high speeds were not necessary or desirable.

It was found from experience, however, that the use of cruising turbines for the low speeds was not an altogether satisfactory solution of the problem of variable speed. The extra complication was found to be a disadvantage, and in recent installations they have not been fitted. Gearing has been adopted in many cases, and exhaustive trials have shown a considerable increase in efficiency both at full and cruising speeds over direct-driven turbine vessels. The propeller efficiency, it was found, could be increased from 8 to 15 per cent, and the steam consumption bettered by about 10 per cent at full power, and by as much as 30 per cent at low powers.

Gearing was universally adopted during the war for destroyers, cruisers, battleships, and battle cruisers of the highest powers, and practically no direct-coupled units have been installed recently.